Package 'StatescopeR'

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Type Package

Title StatescopeR framework for discovery of cell states from cell type-specific gene expression profiles inferred from bulk mRNA profiles

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Description
StatescopeR is an R wrapper around Statescope, a computational framework designed to discover cell states from cell type-specific gene expression profiles inferred from bulk RNA profiles.

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BugReports https://github.com/tgac-vumc/StatescopeR/issues

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Contents

StatescopeR-package . . . 2
barplot_stateloadings . . . 3
BLADE_deconvolution . . . 4
create_signature . . . 6
fetch_signature . . . 7
fraction_eval . . . 7
fraction_heatmap . . . 8
gather_true_fractions . . . 9
Refinement . . . 10
select_genes . . . 11
StateDiscovery . . . 12
statescope . . . 14

Index **15**

`StatescopeR-package` *The StatescopeR package*

Description

framework for discovery of cell states from bulk mRNA profiles

Details

StatescopeR starts from lognormalized cp10k single cell data and a bulk RNA dataset to be used for deconvolution and cell state analysis. From this point StatescopeR has some functions to create a signature and select genes for deconvolution. `create_signature` creates a signature of lognormalized cp10k single cell data for deconvolution and cell state analysis. `select_genes` selects genes which best discriminate cell types for use in deconvolution. Alternatively you can also use: `fetch_signature` to fetch one of the premade signatures + selected_genes from https://github.com/tgac-vumc/StatescopeData After these steps and proper cp10k normalization of the bulk mRNA deconvolution and cell state analysis can be done with the following functions: `BLADE_deconvolution` estimates cell fractions from bulk mRNA. `Refinement` refines cell type-specific gene expression profile estimates to better capture inter-sample variability. `StateDiscovery` discovery cell states from inferred cell type-specific gene expression profiles.

After these steps the following functions provide some evaluation and plotting functions: `gather_true_fractions` gets true cell fractions from scRNAseq data. `fraction_eval` plots the correlation of estimated vs true cell fractionsover all samples. `fraction_heatmap` plots a heatmap of estimated cell fractions. `barplot_stateloadings` plots a barplot showing the top n most important stateloadings.

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See Also

Useful links:

- https://github.com/tgac-vumc/StatescopeR
- Report bugs at https://github.com/tgac-vumc/StatescopeR/issues

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`barplot_stateloadings` *Create a barplot of top stateloadings*

Description

Create a barplot of top stateloadings

Usage

```
barplot_stateloadings(Statescope, top_n = 1)
```

Arguments

`Statescope`	SummarizedExperiment object from StateDiscovery
`top_n`	integer selecting how many genes to show per state

Value

A barplot rendered to the active graphics device

Examples

```
#' ## Load Discovered Statescope object
load(system.file("extdata", "example_Statescope_Discovered.RData",
    package = "StatescopeR"
))

## Plot fraction heatmap
barplot_stateloadings(Statescope, top_n = 1)
```

`BLADE_deconvolution` *Run BLADE deconvolution*

Description

`BLADE_deconvolution.R` Runs BLADE to estimate cell fractions from bulk mRNA

Usage

```
BLADE_deconvolution(
  signature,
  bulk,
  genes,
  prior = NULL,
  cores = 1L,
  Alpha = 1L,
  Alpha0 = 1000L,
  Kappa0 = 1L,
  sY = 1L,
  Nrep = 10L,
  Nrepfinal = 1000L
)
```

Arguments

`signature`	SimpleList with mu and sigma, both nGene x nCelltype dataframes, respectively mean gene expression and mean-variance corrected variance per cell type
`bulk`	nSample x nGene mRNA to be deconvolved
`genes`	subset of genes to be used for deconvolution
`prior`	(optional) nSample x nCelltype matrix with prior fraction expectations
`cores`	number of cores to use for paralellization
`Alpha`	BLADE Hyperparameter
`Alpha0`	BLADE Hyperparameter
`Kappa0`	BLADE Hyperparameter
`sY`	BLADE Hyperparameter
`Nrep`	Number of BLADE initializations
`Nrepfinal`	Number of maximum optimization iterations

Value

SummarizedExperiment object with BLADE output and estimated fractions

Examples

```
if (requireNamespace("scRNAseq", quietly = TRUE)) {
    library(scRNAseq)
    library(scrapper)
    library(edgeR)
    ## Load SegerstolpePancreas data set
    scRNAseq <- SegerstolpePancreasData()

    ## remove duplicate genes
    scRNAseq <- scRNAseq[!duplicated(rownames(scRNAseq)), ]
    ## Subset to 1 healthy and 2 type 2 diabetes samples
    scRNAseq <- scRNAseq[, scRNAseq$individual %in% c(
        "H3",
        "T2D1", "T2D2"
    )]
    ## remove cells with no cell type label
    scRNAseq <- scRNAseq[, !is.na(scRNAseq$`cell type`)]

    ## remove very rare cell types (<100 cells in total data set)
    celltypes_to_remove <-
    names(table(scRNAseq$`cell type`)[(table(scRNAseq$`cell type`) < 100)])
    scRNAseq <- scRNAseq[, !scRNAseq$`cell type` %in% celltypes_to_remove]

    ## Create pseudobulk and normalize to cp10k
    pseudobulk <- scrapper::aggregateAcrossCells.se(scRNAseq,
        factors = scRNAseq$individual)
    assay(pseudobulk, 'normcounts') <-
     edgeR::cpm(assay(pseudobulk, 'sums')) / 100
    colnames(pseudobulk) = pseudobulk$factor.1 # Assign sample names

    ## Load signature
    load(system.file("extdata", "example_signature.RData",
        package = "StatescopeR"
    ))

    ## Load selected_genes
    load(system.file("extdata", "example_selected_genes.RData",
        package = "StatescopeR"
    ))

    ##  Load prior
    load(system.file("extdata", "example_prior.RData",
        package = "StatescopeR"
    ))

    ## Perform Deconvolution with BLADE
    Statescope <- BLADE_deconvolution(
        signature, pseudobulk, selected_genes,
```

```
        prior, 1L,
        Nrep = 1L
    )

    ## show estimated fractions
    S4Vectors::metadata(Statescope)$fractions
}
```

`create_signature` *Create scRNAseq Signature*

Description

`create_signature` Creates signature from scRNAseq data

Usage

```
create_signature(scRNAseq, hvg_genes = FALSE, n_hvg_genes = 3000L, labels)
```

Arguments

`scRNAseq`	SingleCellExperiment object of which to make signature
`hvg_genes`	boolean which chooses if mu and omega should be subset to highly variable genes or not
`n_hvg_genes`	int which allows the users to choose the number of highly variable genes
`labels`	character vector for the cell type labels

Value

SimpleList DataFrames for Mu (mean per gene per cell type) and Omega (variance corrected std.dev per gene per cell type)

Examples

```
if (requireNamespace("scRNAseq", quietly = TRUE)) {
    library(scRNAseq)
    library(edgeR)
    ## Load scRNaseq
    scRNAseq <- scRNAseq::SegerstolpePancreasData()

    ## remove NA cells
    scRNAseq <- scRNAseq[, !is.na(scRNAseq$`cell type`)]

    ## Normalize (cp10k) and logtransform scRNAseq
    cpm(scRNAseq) <- edgeR::cpm(scRNAseq)
    SingleCellExperiment::logcounts(scRNAseq) <- log1p(cpm(scRNAseq) / 100)

    ## Create signature
    signature <- create_signature(scRNAseq, labels = scRNAseq$`cell type`)
}
```

fetch_signature *Fetch scRNAseq Signature*

Description

fetch_signature Fetches signature from StatescopeData repository

Usage

```
fetch_signature(tumor_type, n_celltypes)
```

Arguments

tumor_type	string choosing the tumor type from available signatures at: https://github.com/tgac-vumc/StatescopeData
n_celltypes	integer choosing the number of cell types of the signature from: https://github.com/tgac-vumc/StatescopeData

Value

SimpleList with DataFrames for Mu (mean per gene per cell type) and Omega (variance corrected std.dev per gene per cell type) and vector of selected genes for deconvolution chosen by AutoGeneS

Examples

```
signature <- fetch_signature('PDAC', 7)
selected_genes <- signature$selected_genes
```

fraction_eval *Create a barplot of TRUE vs estimated cfs*

Description

Create a barplot of TRUE vs estimated cfs

Usage

```
fraction_eval(Statescope, true_fractions)
```

Arguments

Statescope	SummarizedExperiment object from BLADE_deconvolution
true_fractions	s4 Dataframe with true fractions to compare with estimated fractions

Value

A barplot rendered to the active graphics device

Examples

```
## Load True fractions
load(system.file("extdata", "example_true_fractions.RData",
    package = "StatescopeR"
))

## Load Deconvolved Statescope object
load(system.file("extdata", "example_Statescope_Deconvolved.RData",
    package = "StatescopeR"
))

## ## Plot fraction correlation and RMSE per ct
fraction_eval(Statescope, true_fractions)
```

`fraction_heatmap` *Create a heatmap of the estimated fractions*

Description

Create a heatmap of the estimated fractions

Usage

```
fraction_heatmap(Statescope, ...)
```

Arguments

`Statescope`	SummarizedExperiment object from BLADE_deconvolution
`...`	other parameters to pass to [ComplexHeatmap::Heatmap()]

Value

A heatmap rendered to the active graphics device

Examples

```
## Load Deconvolved Statescope object
load(system.file("extdata", "example_Statescope_Deconvolved.RData",
    package = "StatescopeR"
))

## Plot fraction heatmap
fraction_heatmap(Statescope)
```

gather_true_fractions *Gather true fractions*

Description

gather_true_fractions Gathers true fractions of all cell types per sample from scRNAseq data

Usage

```
gather_true_fractions(scRNAseq, ids, label_col)
```

Arguments

scRNAseq	SingleCellExperiment object of which to gather fractions per sample
ids	character vector with ids of samples
label_col	character for the column name with the cell type labels

Value

DataFrame with fractions of all cell types per sample

Examples

```
if (requireNamespace("scRNAseq", quietly = TRUE)) {
    library(scRNAseq)
    ## Load data
    scRNAseq <- scRNAseq::SegerstolpePancreasData()
    ## Subset to 1 healthy and 3 type 2 diabetes samples
    scRNAseq <- scRNAseq[, scRNAseq$individual %in% c(
        "H3",
        "T2D1", "T2D2"
    )]
    ## remove NA cells
    scRNAseq <- scRNAseq[, !is.na(scRNAseq$`cell type`)]

    ## remove cells with less than 100 in total cohort
    celltypes_to_remove <- names(table(scRNAseq$`cell type`)
    [(table(scRNAseq$`cell type`) < 100)])
    scRNAseq <- scRNAseq[, !scRNAseq$`cell type` %in% celltypes_to_remove]

    true_fractions <- gather_true_fractions(scRNAseq,
        ids = scRNAseq$individual, label_col = "cell type"
    )
}
```

`Refinement` *Run Refinement*

Description

`Refinement.R` # Perform Gene Expression Refinement

Usage

```
Refinement(Statescope, signature, bulk, cores = 1L)
```

Arguments

`Statescope`	SummarizedExperiment object from BLADE_deconvolution
`signature`	SimpleList with mu and sigma, respectively mean gene expression and mean-variance corrected variance per cell type
`bulk`	mRNA to be refined
`cores`	number of cores to use for paralellization

Details

This function takes the output from BLADE_deconvolution and refines the cell type specific gene expression by reoptimizing the initial estimates. It reoptimzes by fixing the estimated fractions and weighing the objective function value in a way that it tries to resemble the bulk RNA expression more than initially

Value

updated SummarizedExperiment object with ct_specific_gep added

Examples

```
if (requireNamespace("scRNAseq", quietly = TRUE)) {
    library(scRNAseq)
    library(scrapper)
    library(edgeR)
    ## Load SegerstolpePancreas data set
    scRNAseq <- SegerstolpePancreasData()

    ## remove duplicate genes
    scRNAseq <- scRNAseq[!duplicated(rownames(scRNAseq)), ]

    ## Subset to 1 healthy and 2 type 2 diabetes samples
    scRNAseq <- scRNAseq[, scRNAseq$individual %in% c(
        "H3",
        "T2D1", "T2D2"
    )]
    ## remove cells with no cell type label
```

```
    scRNAseq <- scRNAseq[, !is.na(scRNAseq$`cell type`)]

    ## remove very rare cell types (<100 cells in total data set)
    celltypes_to_remove <- names(table(scRNAseq$`cell type`)
    [(table(scRNAseq$`cell type`) < 100)])
    scRNAseq <- scRNAseq[, !scRNAseq$`cell type` %in% celltypes_to_remove]

    ## Create pseudobulk and normalize to cp10k
    pseudobulk <- scrapper::aggregateAcrossCells.se(scRNAseq,
        factors = scRNAseq$individual)
    assay(pseudobulk, 'normcounts') <- edgeR::cpm(assay(pseudobulk, 'sums')) / 100
    colnames(pseudobulk) = pseudobulk$factor.1 # Assign sample names

    ## Load signature
    load(system.file("extdata", "example_signature.RData",
        package = "StatescopeR"
    ))

    ## Load Deconvolved Statescope object
    load(system.file("extdata", "example_Statescope_Deconvolved.RData",
        package = "StatescopeR"
    ))

    ## Run Refinement
    Statescope <- Refinement(Statescope, signature, pseudobulk, 2L)

    ## Show cell type specific gene expression profile estimates
    S4Vectors::metadata(Statescope)$ct_specific_gep
}
```

`select_genes` *Select genes using AutoGeneS*

Description

`select_genes.R` select genes using AutoGeneS for deconvolution

Usage

```
select_genes(scRNAseq, fixed_n_features = NA, n_hvg_genes = 3000L, labels)
```

Arguments

`scRNAseq`	SingleCellExperiment object to use for gene selection, should be same as signature dataset
`fixed_n_features`	integer number of genes to pick with autogenes, default is NA which lets autogenes itself pick
`n_hvg_genes`	int which allows the users to choose the number of highly variable genes
`labels`	character vector with cell type labels

Value

Vector of genes to use for deconvolution

Examples

```
if (requireNamespace("scRNAseq", quietly = TRUE)) {
    library(scRNAseq)
    library(edgeR)
    ## Load SegerstolpePancreas data set
    scRNAseq <- SegerstolpePancreasData()

    ## remove duplicate genes
    scRNAseq <- scRNAseq[!duplicated(rownames(scRNAseq)), ]

    ## Subset to 1 healthy and 2 type 2 diabetes samples
    scRNAseq <- scRNAseq[, scRNAseq$individual %in% c(
        "H3",
        "T2D1", "T2D2"
    )]
    ## remove cells with no cell type label
    scRNAseq <- scRNAseq[, !is.na(scRNAseq$`cell type`)]

    ## remove rare cell types (<100 cells in total data set)
    celltypes_to_remove <-names(table(scRNAseq$`cell type`)
        [(table(scRNAseq$`cell type`) < 100)])
    scRNAseq <- scRNAseq[, !scRNAseq$`cell type` %in% celltypes_to_remove]

    ## remove NA cells
    scRNAseq <- scRNAseq[, !is.na(scRNAseq$`cell type`)]

    ## Normalize (cp10k) and logtransform scRNAseq
    cpm(scRNAseq) <- edgeR::cpm(scRNAseq)
    logcounts(scRNAseq) <- log1p(cpm(scRNAseq) / 100)

    ## Select genes by autogenes
    selected_genes <- select_genes(scRNAseq, 3L,
        n_hvg_genes = 5L,
        labels = scRNAseq$`cell type`
    ) # 3 genes
}
```

`StateDiscovery` *Run StateDiscovery*

Description

`StateDiscovery.R` Discovers states from refined ct-specific gep

Usage

```
StateDiscovery(
  Statescope,
  k = NA,
  max_clusters = 10L,
  n_iter = 10L,
  n_final_iter = 100L,
  min_cophenetic = 0.9,
  Ncores = 1L
)
```

Arguments

Statescope	SummarizedExperiment object from Statescope Refinement.
k	number of cluster to choose, default is NA for automatic selection
max_clusters	maximum allowed states per cell type.
n_iter	Number of initial cNMF restarts.
n_final_iter	Number of final cNMF restarts.
min_cophenetic	Minimum cophenetic coefficient to determine K.
Ncores	number of cores to use for paralellization.

Value

SummarizedExperiment object with statescores per celltype added

Examples

```
## Load Refined Statescope object
load(system.file("extdata", "example_Statescope_Refined.RData",
    package = "StatescopeR"
))

## Discover states
Statescope <- StateDiscovery(Statescope, k = 2L, Ncores = 2L)

## Look at statescores and stateloadings
S4Vectors::metadata(Statescope)$statescores
S4Vectors::metadata(Statescope)$stateloadings
```

`statescope` *Python environments*

Description

Python environments

Usage

```
statescope
```

Index

∗ **internal**
StatescopeR-package, 2

barplot_stateloadings, *3*, 3
BLADE_deconvolution, *2*, 4

create_signature, *2*, 6

fetch_signature, *2*, 7
fraction_eval, *3*, 7
fraction_heatmap, *3*, 8

gather_true_fractions, *3*, 9

Refinement, *2*, 10

select_genes, *2*, 11
StateDiscovery, *2*, 12
statescope, 14
StatescopeR *(*StatescopeR-package*)*, 2
StatescopeR-package, 2